Measurement of Fugitive and Area Sources

NIST GHG Measurements Workshop
March 25, 2010

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Measurement of Fugitive and Area Sources
Acknowledgments

- Robin Segall, Jason DeWees - EPA Office of Air Quality Planning and Standards
- Bill Mitchell, Buddy Thompson, Bill Squier, Susan Thorneloe - EPA ORD
- Gary Hater, Roger Green - Waste Management (EPA CRADA #372-A-08)
- Rod Robinson - National Physical Laboratory of UK
- Chris Rella, Eric Crosson - Picarro
- Dave Nelson - Aerodyne Research
- Hamish Adam, Chris Parker - Boreal Laser (EPA CRADA #339-05)
- Rich Grant, University of Purdue
- Ken Casey, Brock Faulkner, University of Texas A&M
- Ray Merrill, Dave Dayton - Eastern Research Group (EP-C-07-015)
- Mark Modrak, Shahrooz Amin – Arcadis (EP-C-09-027)
- Ram Hashmonay – Environ (formally Arcadis)

Developing GHG Measurements Methods for Fugitive and Areas Sources

United States Environmental Protection Agency

Drivers

- Improve GHG inventories for difficult source categories
- Verify GHG offsets and overall reductions
- Reduce GHG emissions with better fugitive / process control

Improved GHG measurement methods benefit air quality by directly reducing co-emitted pollutants and by advancing assessment methods

Fugitive and Area GHG Sources (many forms)

United States Environmental Protection Agency

Includes: **Difficult to estimate**

landfills, agriculture, industrial fugitive, coal mining, waste water, oil and gas production

Excludes: **Easy to estimate**

Point sources, stack emissions, mobile sources

Similarities of Fugitive and Area Sources

- Spatially Variable
  - Fugitive -- unknown location
  - Area Source -- delocalized emissions, heterogeneous
- Temporally Variable
  - Fugitive -- sudden onset / episodic / process
  - Area Source -- diurnal / seasonal / atmospheric / process
- Variability Drives Emission Uncertainty
  - Difficult to measure
  - Difficult to model

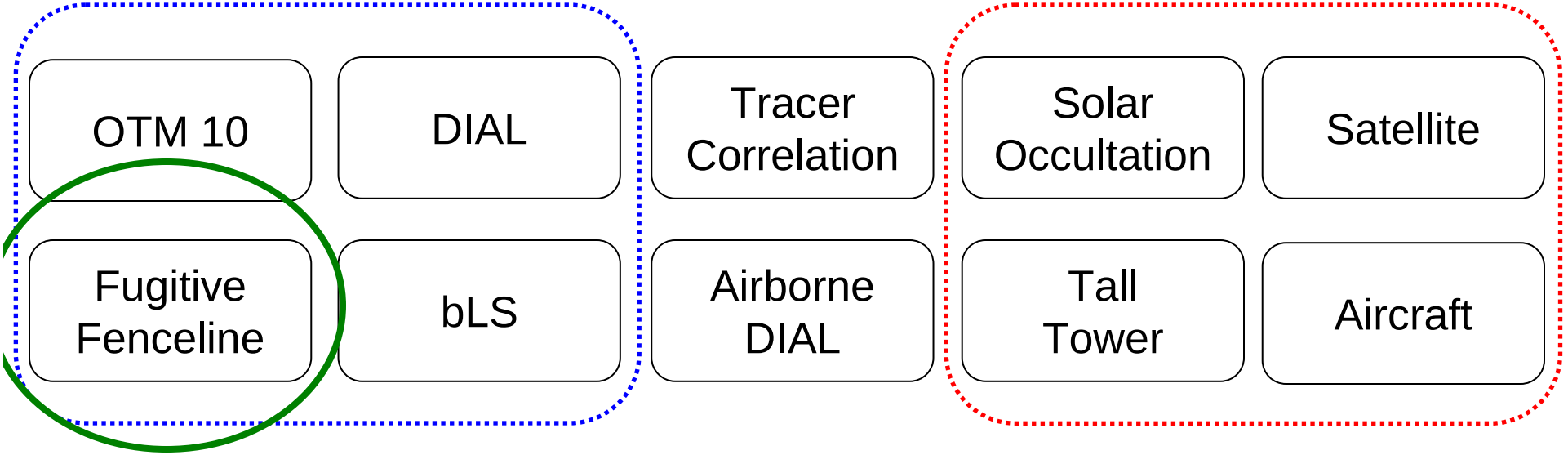
Fugitive and Area Source Spatial Scale

- Fugitive Sources
  - Site -- point leaks in large facilities (1km)
  - Distributed -- point leaks in large area (10 km)
- Area Sources
  - Small (0.1- 0.3 km)
  - Large (0.3 - 2 km)
- Extended Area Source/Sink (> 2 km)

Remote Sensing Emission Assessment

- defined source
- 0.01 m to ≈1 km
- direct observation
- high resolution

- undefined source
- >> 1 km to large scale
- indirect observation
- low resolution



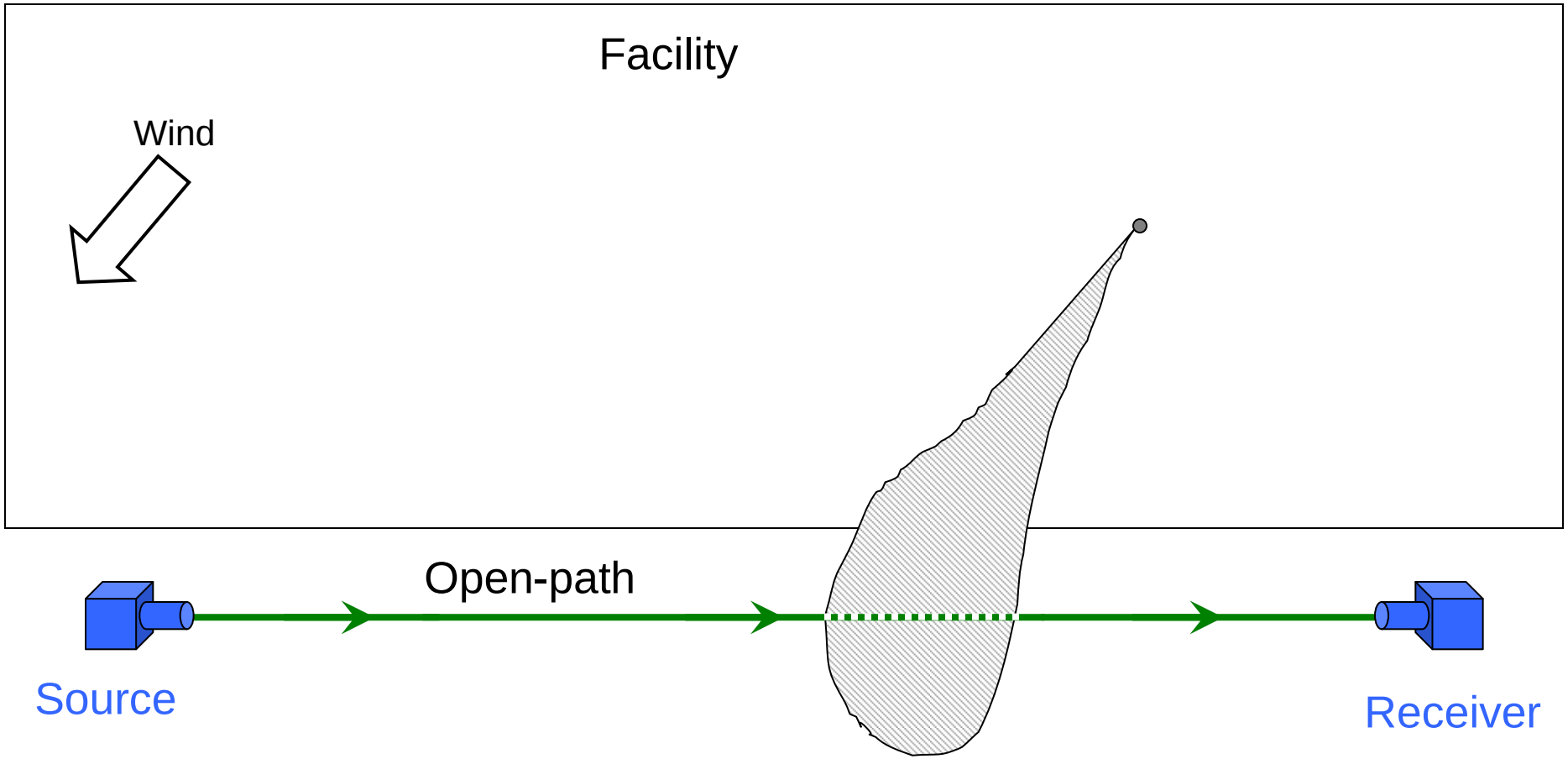
Fugitive Leak Detection and Repair (LDAR)

Mid-IR camcorder

Allows visualization of fugitive sources

Forward-Looking
InfraRed
(leak imaging)

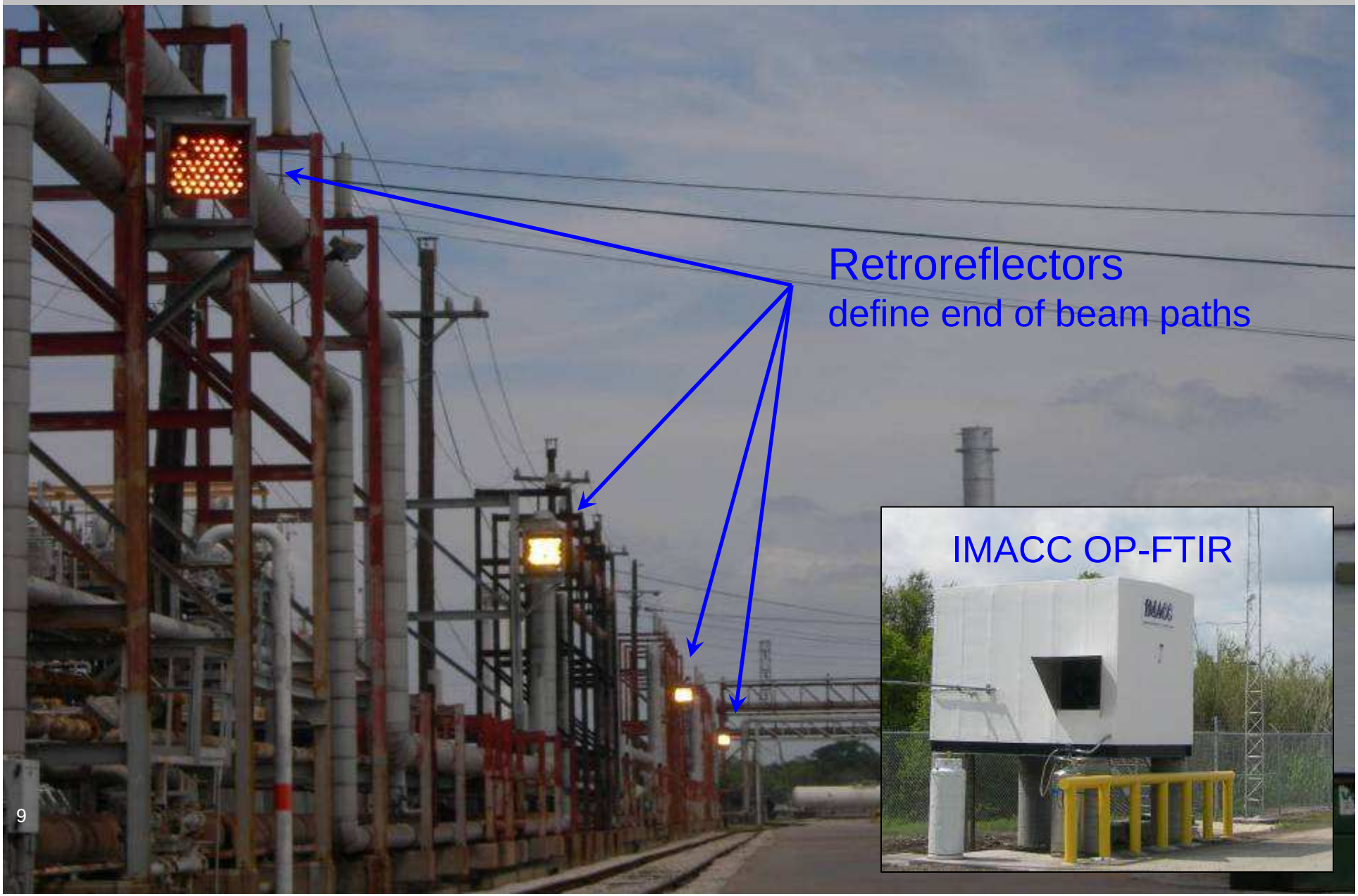
Open-path Fenceline Monitoring Informs LDAR



Simplified and Low Cost Optical Remote Sensing Technology for Fenceline Monitoring of Fugitive Releases, W. A. Mitchell, E. D. Thoma, et al., Air & Waste Manage Assoc. Conf. June 22-25, 2010 - Calgary, Alberta, Canada

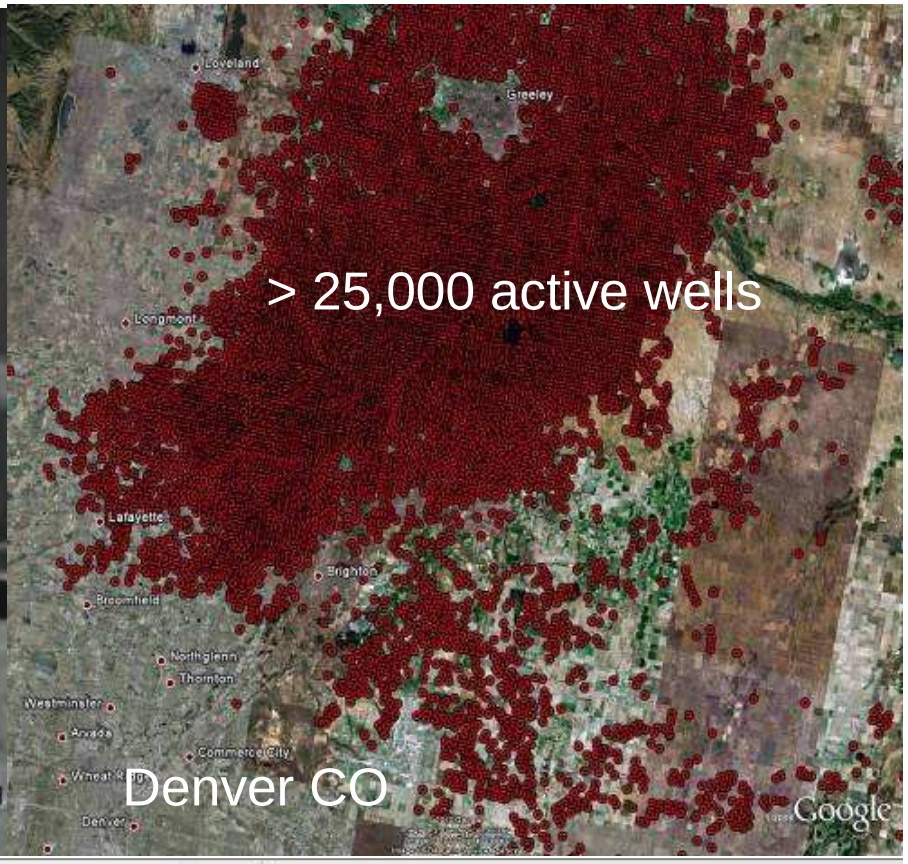
Long-term Monitoring for Fugitive Emissions

Open-path FTIR fenceline system at Texas Petrochemical, Houston TX.



Distributed Fugitives: Oil and Gas Production

United States Environmental Protection Agency



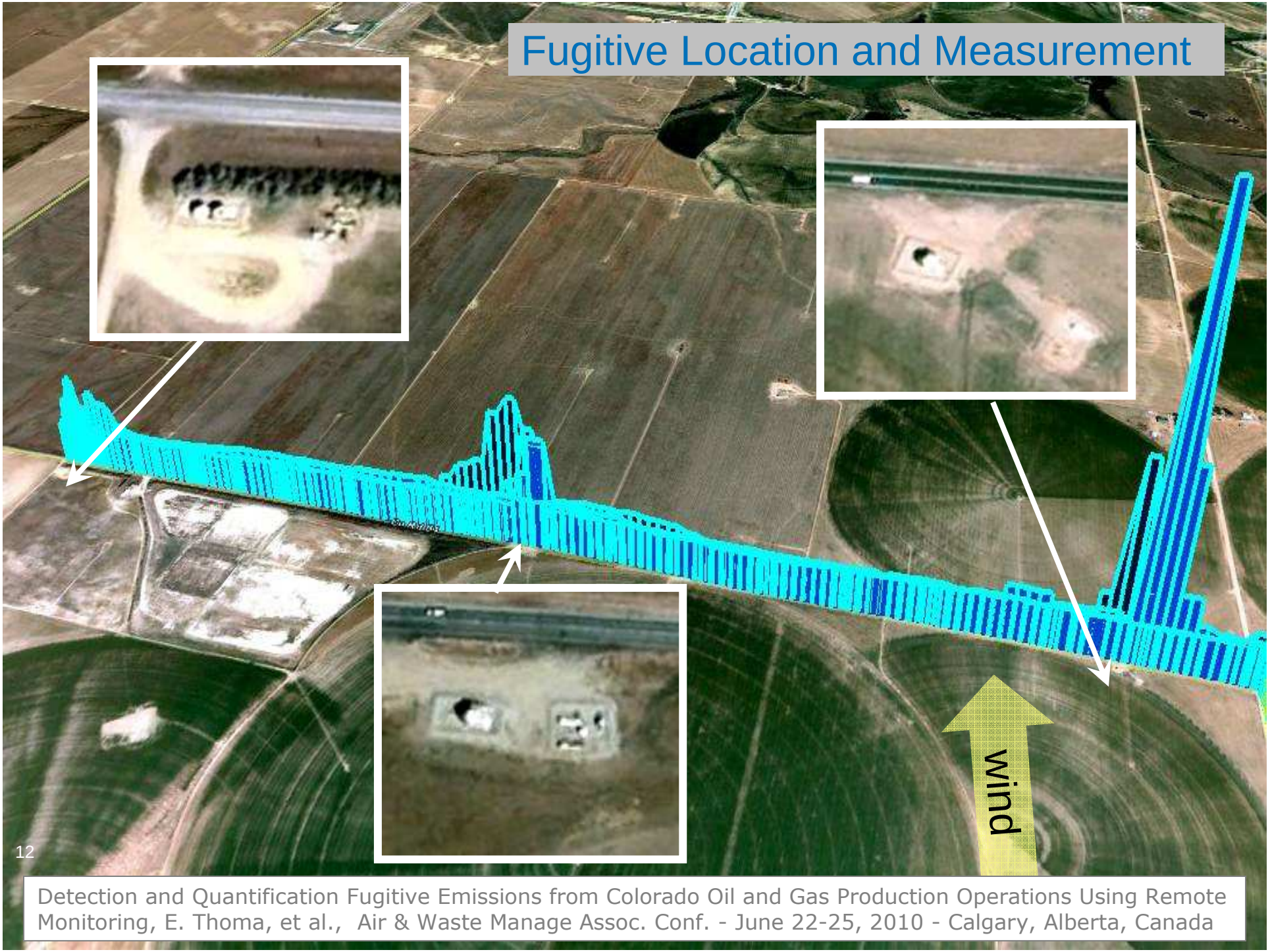
EPA EP-C-09-27, Greeley CO, Nov. 2009

Fugitive Location and Measurement

- mobile CH_4 measurement
- mapping / statistics
- fast CRDS with met and GPS
- cost effective and transferable

O&G Production Site Fugitive Emission Assessment
EPA/ORD/NRMRL EP-C-09-027 WA 0-43

Fugitive Location and Measurement



Detection and Quantification Fugitive Emissions from Colorado Oil and Gas Production Operations Using Remote Monitoring, E. Thoma, et al., Air & Waste Manage Assoc. Conf. - June 22-25, 2010 - Calgary, Alberta, Canada

Remote Sensing Emission Assessment

- defined source
- 0.01 m to ≈1 km
- direct observation
- high resolution

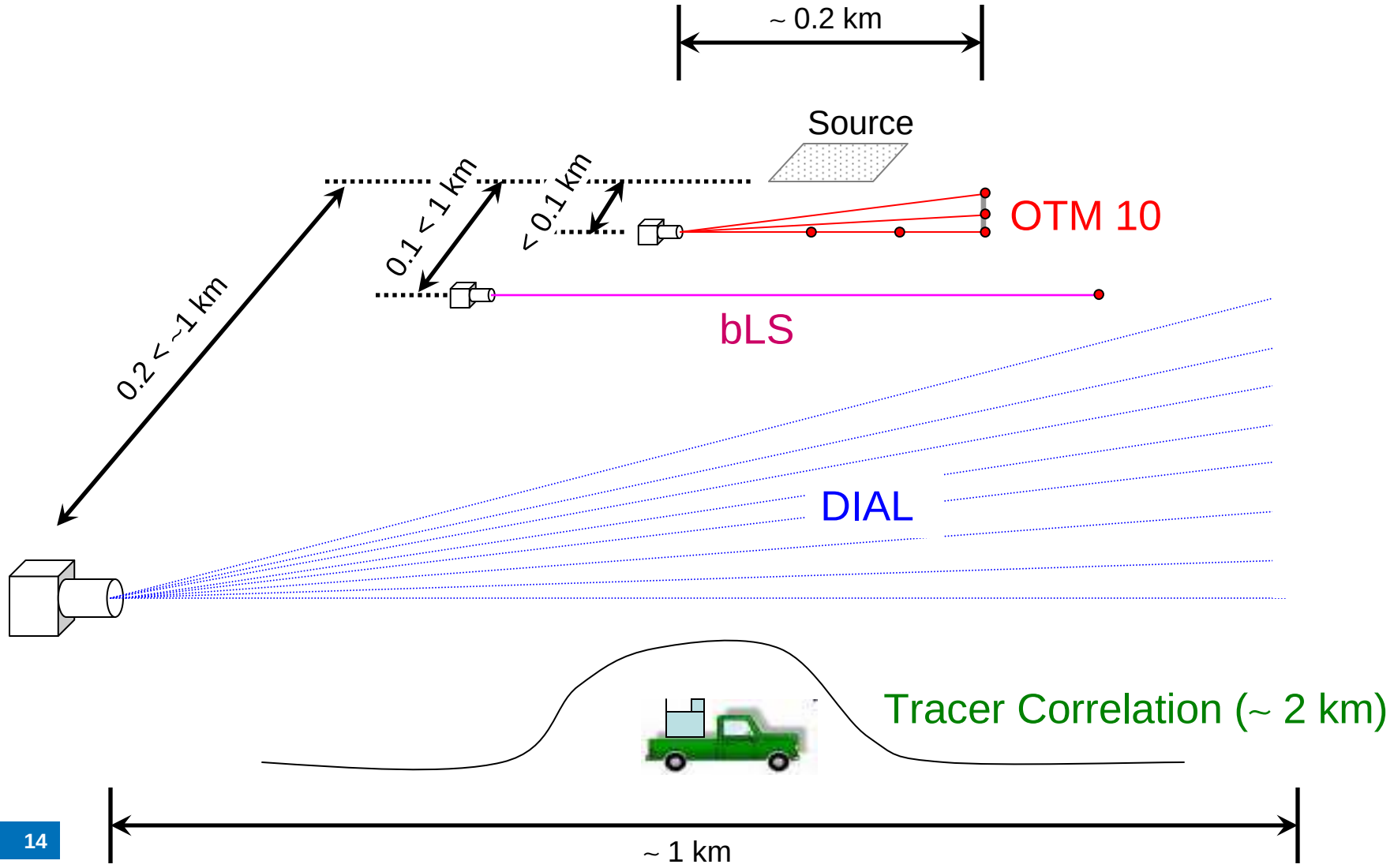
Ranges from:
small area source to facility assessment

Close coupled -- OTM 10
> km standoff -- tracer correlation

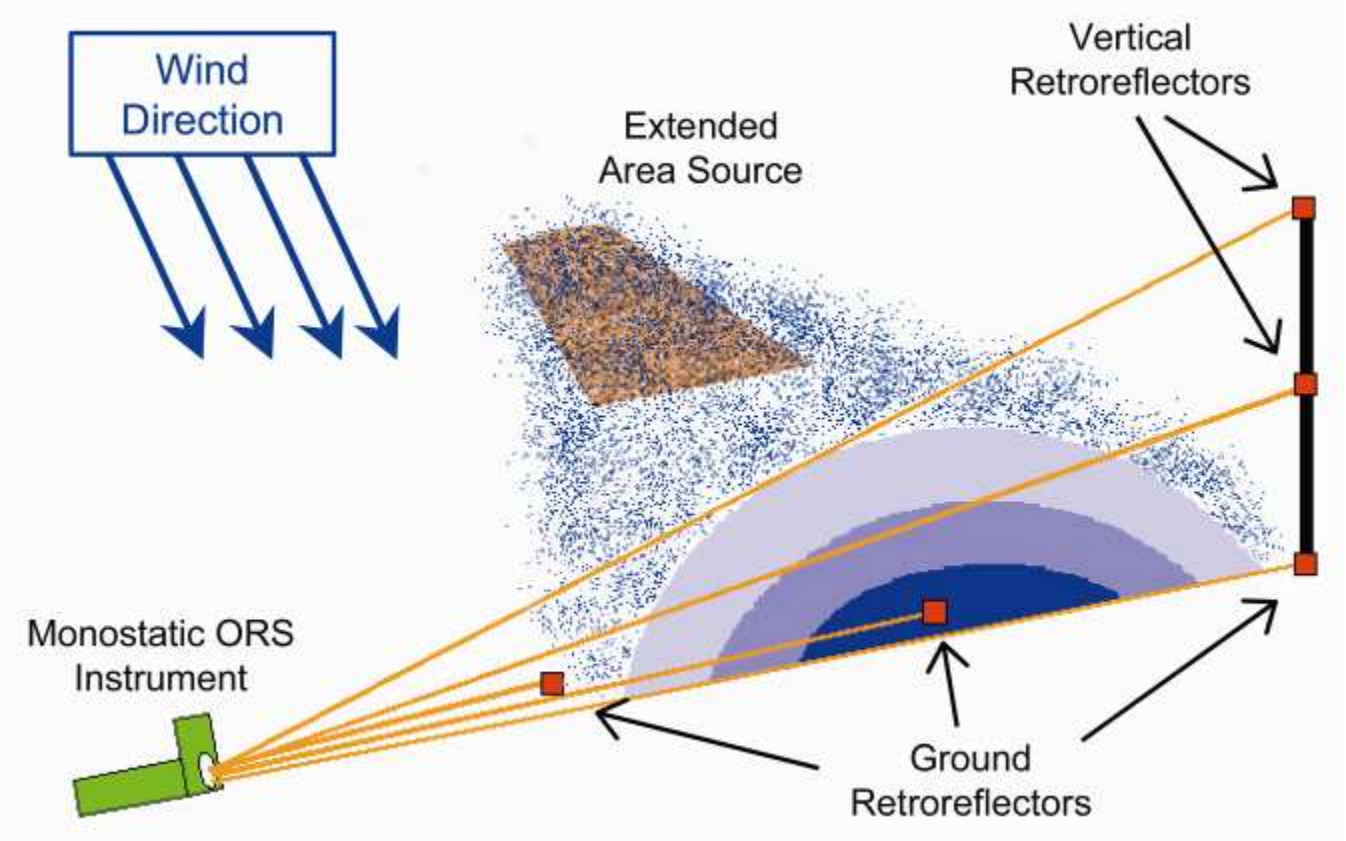
OTM 10	DIAL	Tracer Correlation	Solar Occultation	Satellite
Fugitive Fenceline	bLS	Airborne DIAL	Tall Tower	Aircraft

Remote Emission Measurements

OTM 10, bLS, DIAL, Tracer Correlation

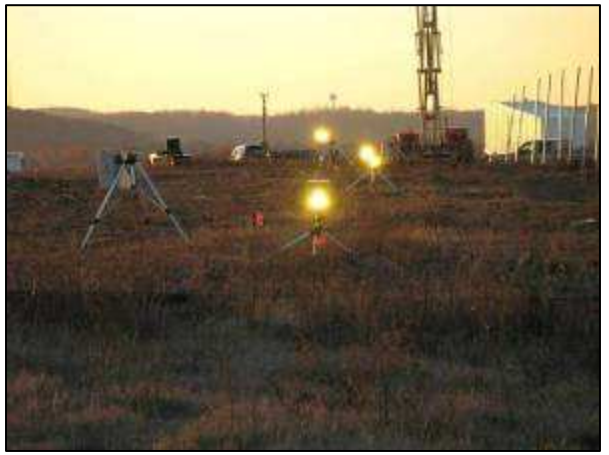


EPA OTM 10
vertical radial plume mapping



Optical remote sensing for emission characterization from non-point sources
EPA OTM 10,(2006), http://www.epa.gov/ttn/emc/prelim/otm10.pdf

Typical OTM 10 Application
Measuring CH_4 emissions from part of landfill

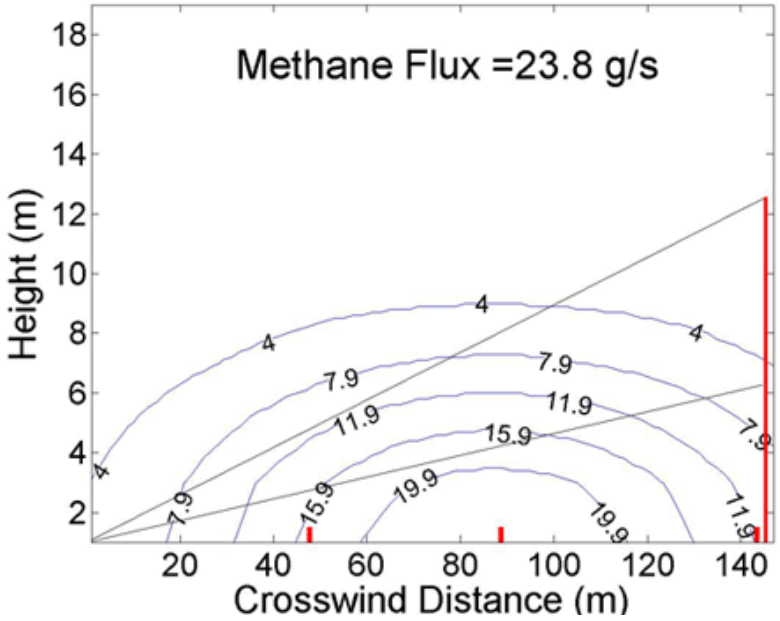


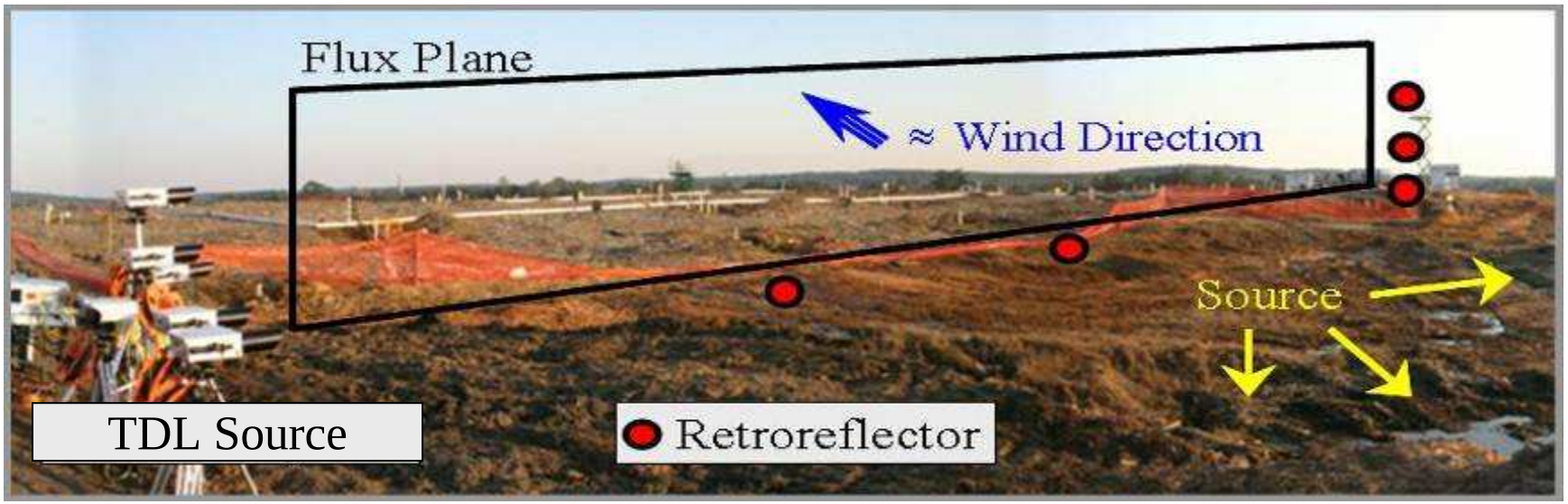
Open-Path Tunable Diode Laser Absorption Spectroscopy for Acquisition of Fugitive Emission Flux Data, E. Thoma, et al., Jor. of the Air and Waste Manage Assoc 55, 658-668 (2005).

Evaluation of Fugitive Emissions Using Ground-Based Optical Remote Sensing, U.S. EPA Report EPA/600/R-07/032 (2007), at Web Site: http://www.epa.gov/nrmrl/pubs/600r07032/600r07032.pdf

OTM10 Example -- Landfill Bioreactor Cell

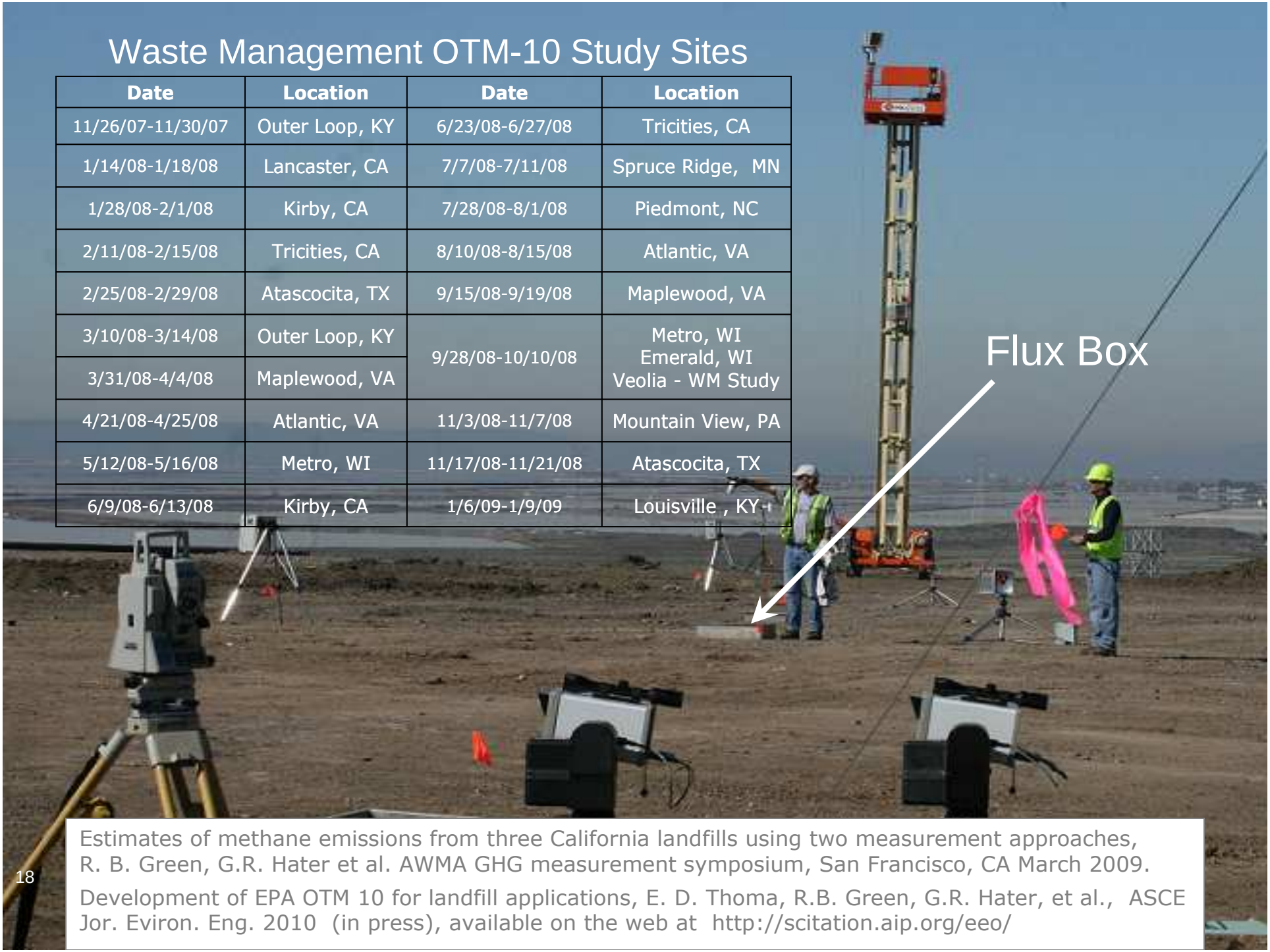
- Experimental Municipal Bioreactor (not typical)
- Air and leachate injection
- Open wells on side slope





Waste Management OTM-10 Study Sites

Date	Location	Date	Location
11/26/07-11/30/07	Outer Loop, KY	6/23/08-6/27/08	Tricities, CA
1/14/08-1/18/08	Lancaster, CA	7/7/08-7/11/08	Spruce Ridge, MN
1/28/08-2/1/08	Kirby, CA	7/28/08-8/1/08	Piedmont, NC
2/11/08-2/15/08	Tricities, CA	8/10/08-8/15/08	Atlantic, VA
2/25/08-2/29/08	Atascocita, TX	9/15/08-9/19/08	Maplewood, VA
3/10/08-3/14/08	Outer Loop, KY	9/28/08-10/10/08	Metro, WI Emerald, WI Veolia - WM Study
3/31/08-4/4/08	Maplewood, VA		
4/21/08-4/25/08	Atlantic, VA	11/3/08-11/7/08	Mountain View, PA
5/12/08-5/16/08	Metro, WI	11/17/08-11/21/08	Atascocita, TX
6/9/08-6/13/08	Kirby, CA	1/6/09-1/9/09	Louisville , KY



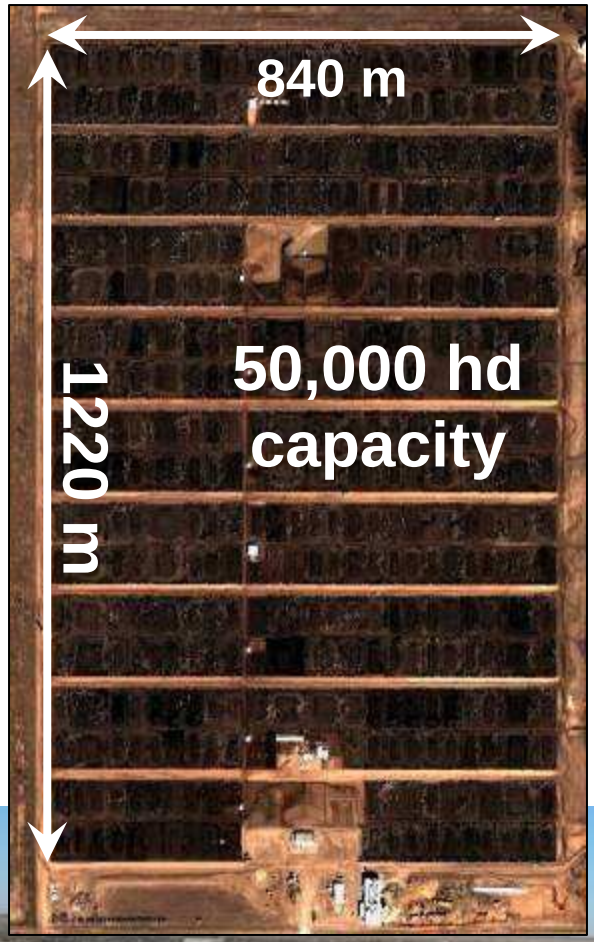
Estimates of methane emissions from three California landfills using two measurement approaches, R. B. Green, G.R. Hater et al. AWMA GHG measurement symposium, San Francisco, CA March 2009.

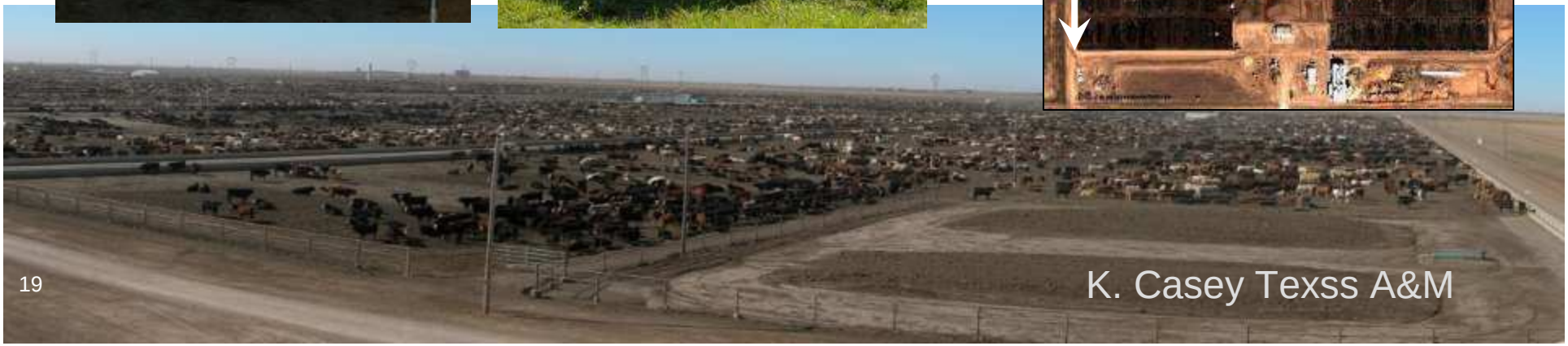
Development of EPA OTM 10 for landfill applications, E. D. Thoma, R.B. Green, G.R. Hater, et al., ASCE Jor. Eviron. Eng. 2010 (in press), available on the web at http://scitation.aip.org/eeo/

bLS Example: N_20 Emission from Feedlot

United States Environmental Protection Agency

- Can long-path OP-FTIR and bLS quantify N_2O from feedlots?
- Can advanced retrieval algorithms help?
- New large format source for > km path



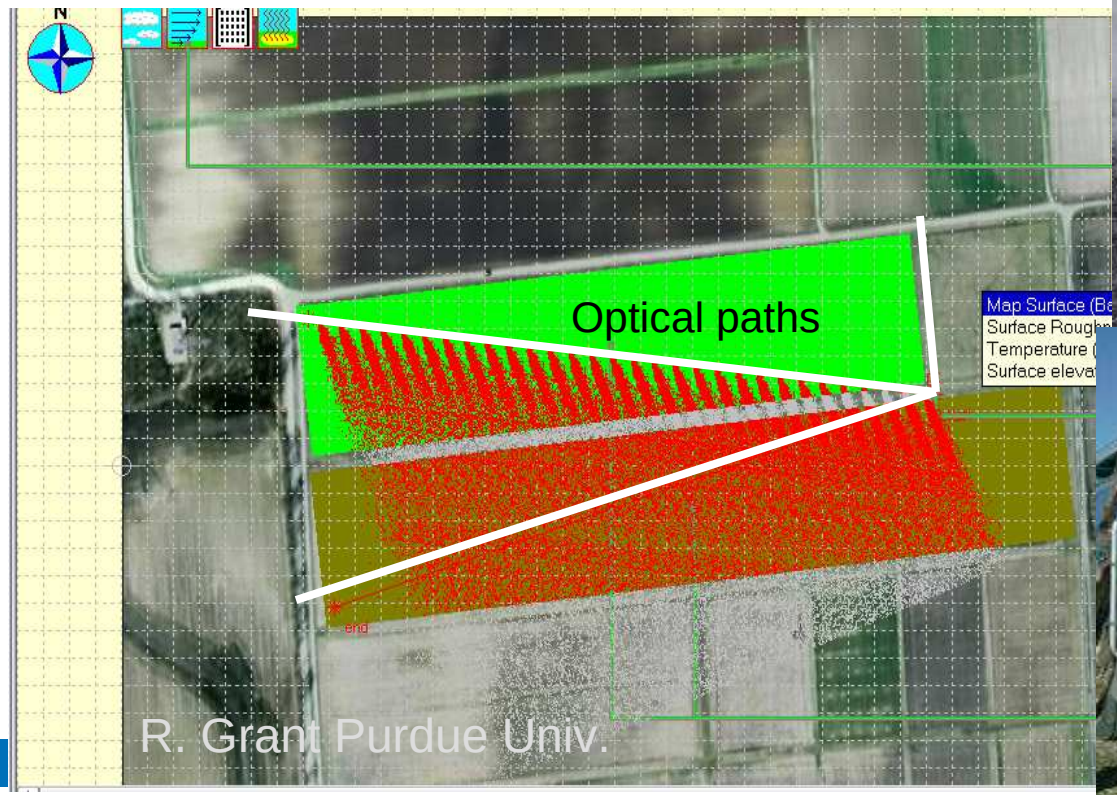


K. Casey Texss A&M

bLS Example: N_20 Emissions from Fertilization

University of Purdue / EPA Open path FITR pilot study 2010

- Can scanning OP-FTIR and bLS quantity GHG emissions?
- Baseline 320 ppb, 3 ppb σ, 300 m path 0.5 cm^{-1}

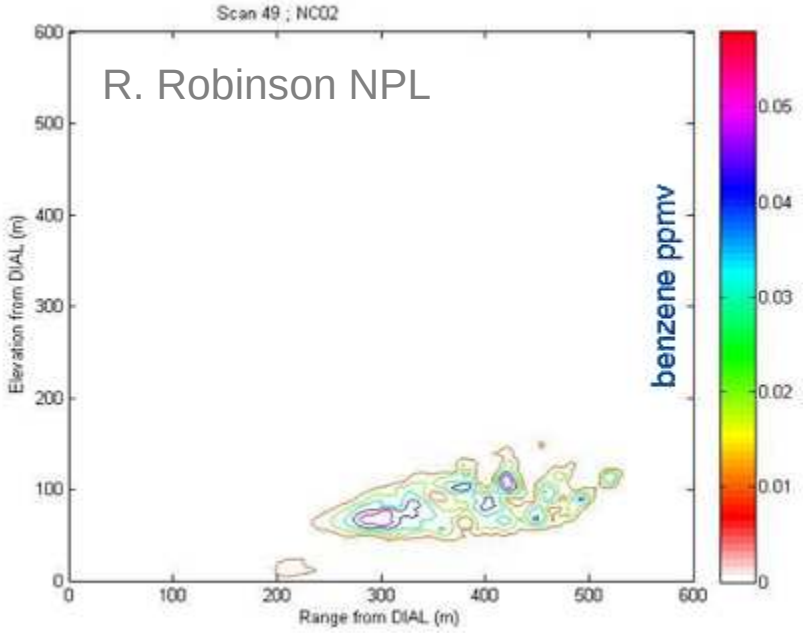


Differential Absorption LIDAR (DIAL)

National Physical Laboratory (NPL) of the UK

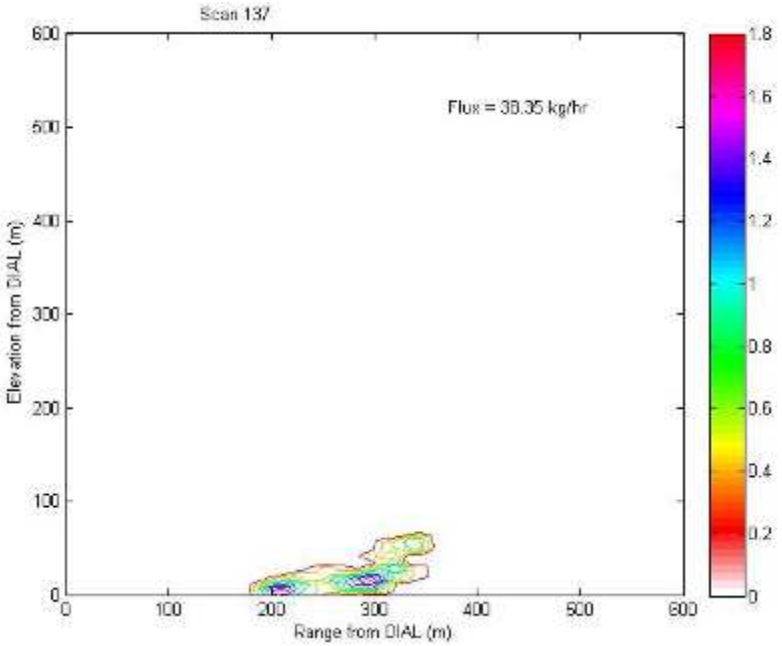
- NPL– Flux meas. DIAL since mid 1980's
  - System design and fabrication
  - Method / protocol development
  - Technique validation
  - Field measurement services
- Methane, ethene, methanol, VOCs, SO_2, NO_2, NO, Hg, HCl, BTEX
- Spatial resolution < 4 meters
- Range up to 3 km
- Measurement sensitivity typically 50 ppbv

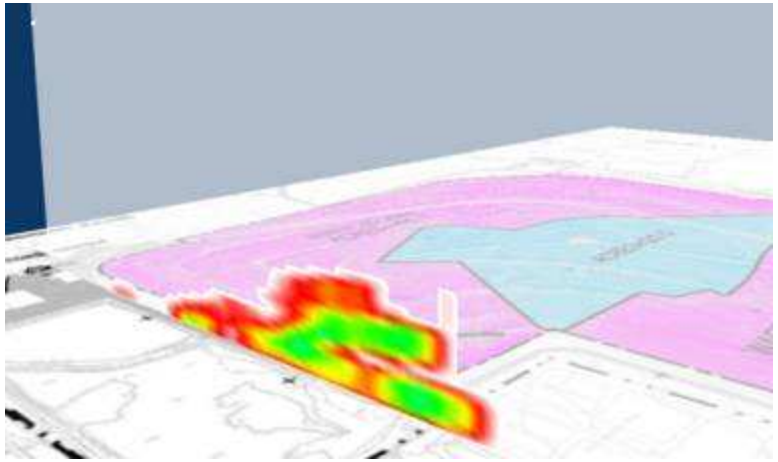
Open path test cell



NPL DIAL for methane from landfills

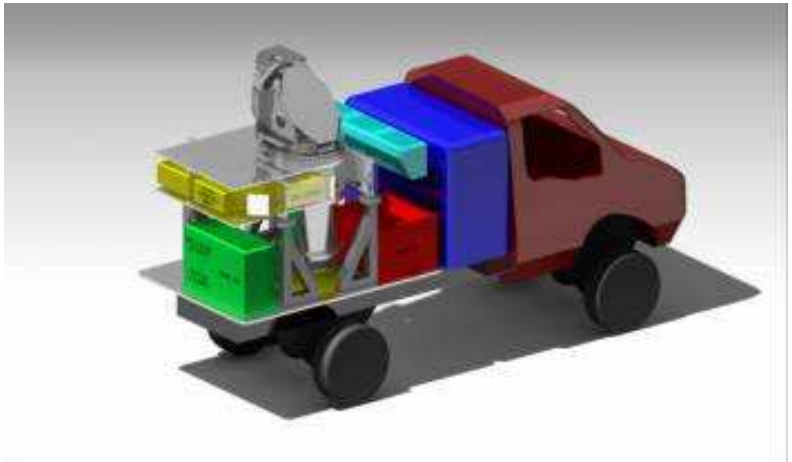
- Recent field campaigns in UK, France (6) and USA (2) have demonstrated use of DIAL for measurement of methane emissions from landfills
- Able to map methane emissions and identify ‘hotspots’ by scanning horizontally across the site.
- Provide quantified measurement of emissions flux
- Measured levels of emissions from ‘active’ areas and from capped areas





Future development of GHG DIAL at NPL

- Compact GHG DIAL (CH_4, CO_2, N_2O)
  - Current research program (pilot stage)
  - Better sensitivity – new components
  - Less flexible than current DIAL
  - Modular - focussed sub system design
  - Cost effective - transferable

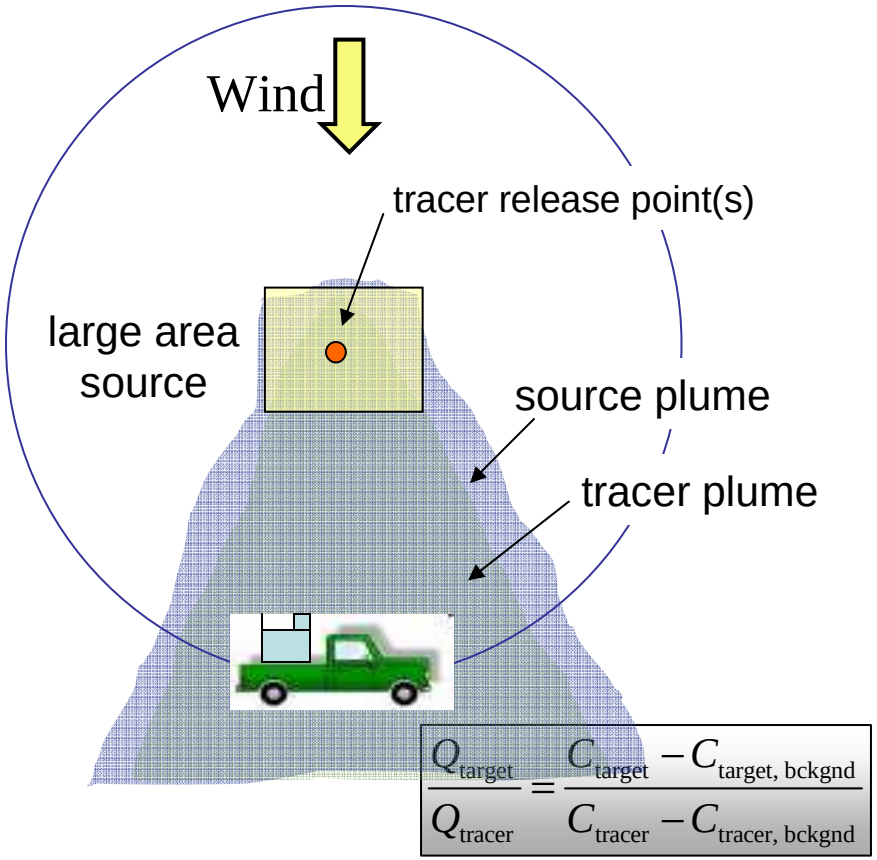


- Method development
  - Improved analysis algorithms
  - Advanced wind field measurement
  - Uncertainty determination
  - Flux measurement in complex environment

NPL Contact: Rod Robinson -- rod.robinson@npl.co.uk

Mobile and Stationary Tracer Correlation

- Release tracer gas from strategic locations within the facility
- Use mobile monitor to map target source and tracer plumes
- Calculate dilution ratio based on known tracer rate
- EPA method development research
  Waste Management CRADA #372-A-08, EP-C-07-15 WA 2-10



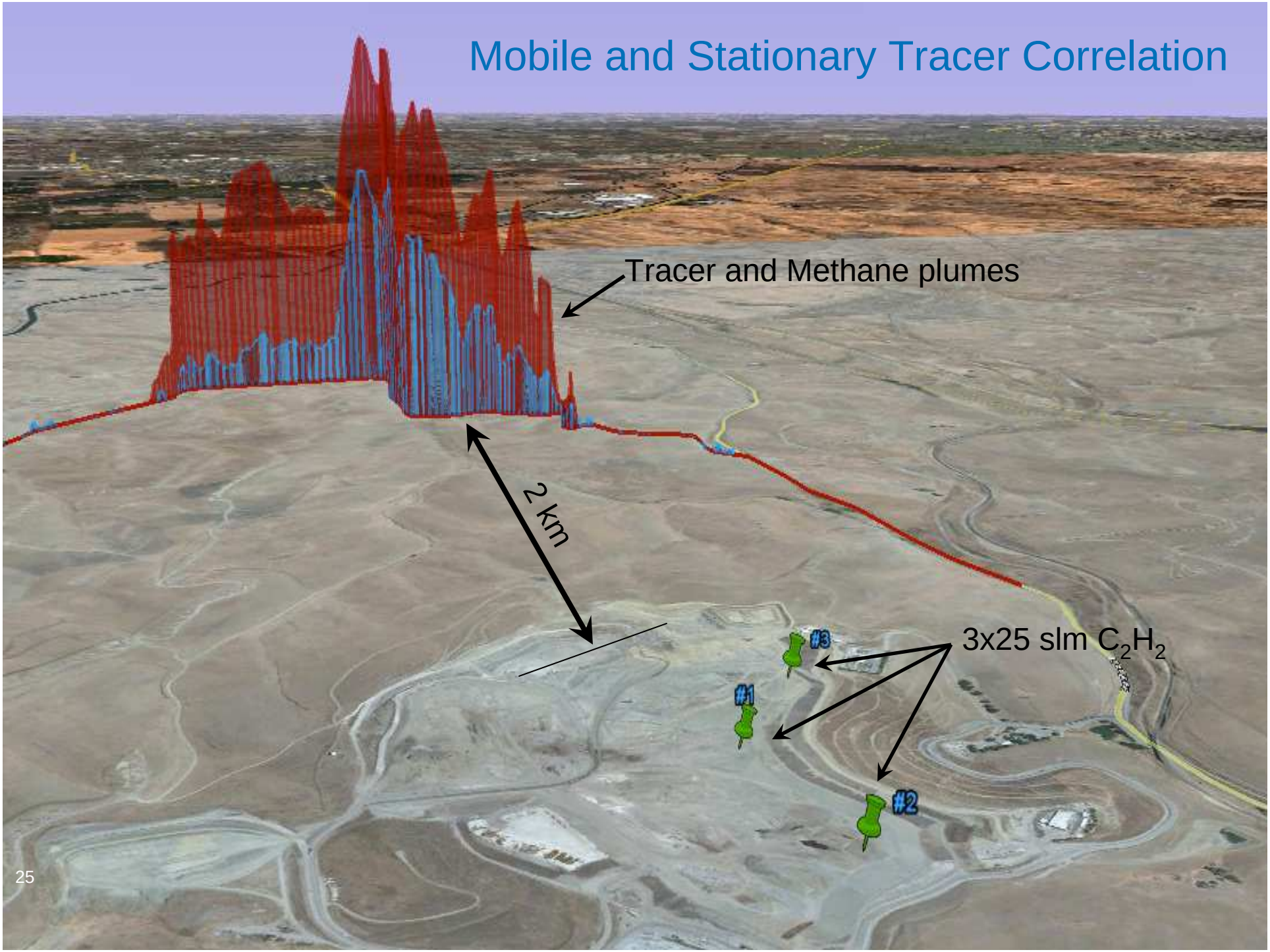
$$\frac{Q_{target}}{Q_{tracer}} = \frac{C_{target} - C_{target,\ bckgnd}}{C_{tracer} - C_{tracer,\ bckgnd}}$$

Quantifying Methane Fluxes Simply and Accurately, The Tracer Dilution Method, C. W. Rella, E. R. Crosson, et al. European Geophysical Union Meeting, 2–7 May 2010, Vienna, Austria.

Methane Emissions at Nine Landfill Sites in the Northeastern United States, B.W. Mosher, P.M. Czepiel, et al. Environ. Sci. Technol. 1999, 33, 2088–2094.

Measurements of Methane Emissions from Landfills Using a Time Correlation Tracer Method Based on FTIR Absorption Spectroscopy, B. Galle, B.; J. Samuelsson, et al. Environ. Sci. Technol. 2001, 35, 21-25.

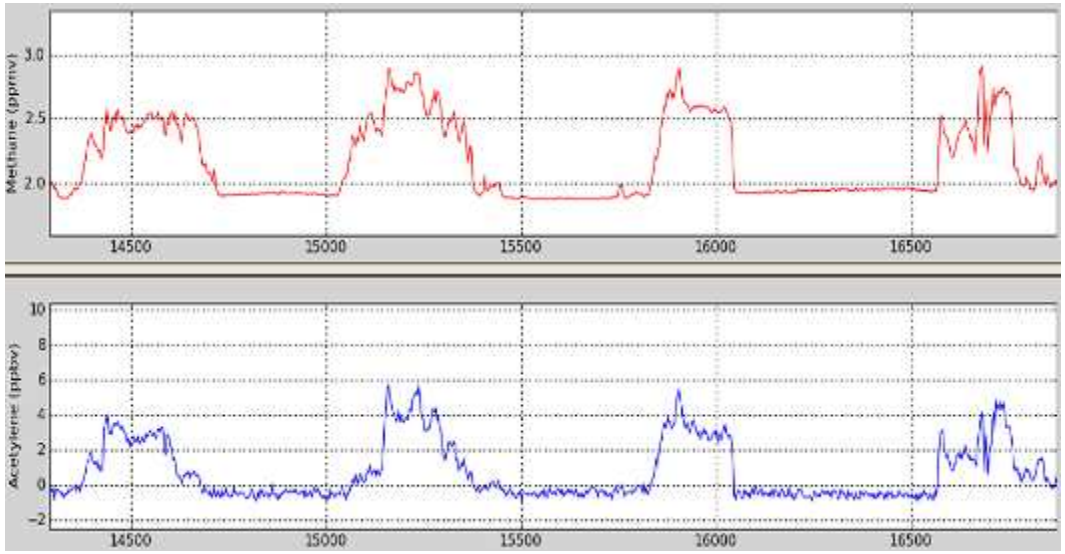
Mobile and Stationary Tracer Correlation

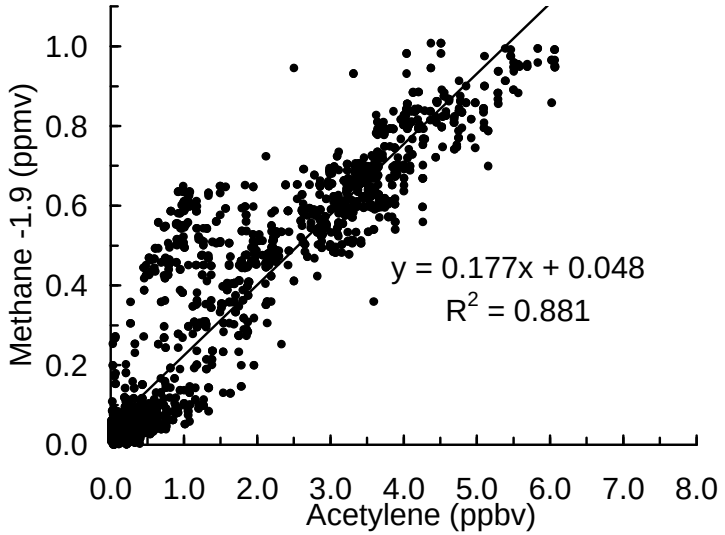


Mobile and Stationary Tracer Correlation

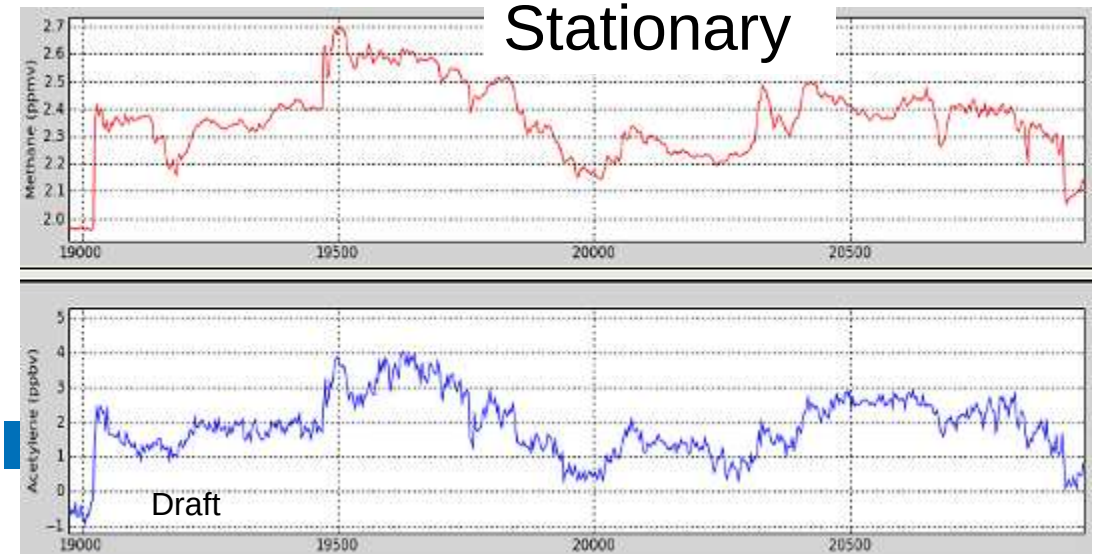
United States Environmental Protection Agency

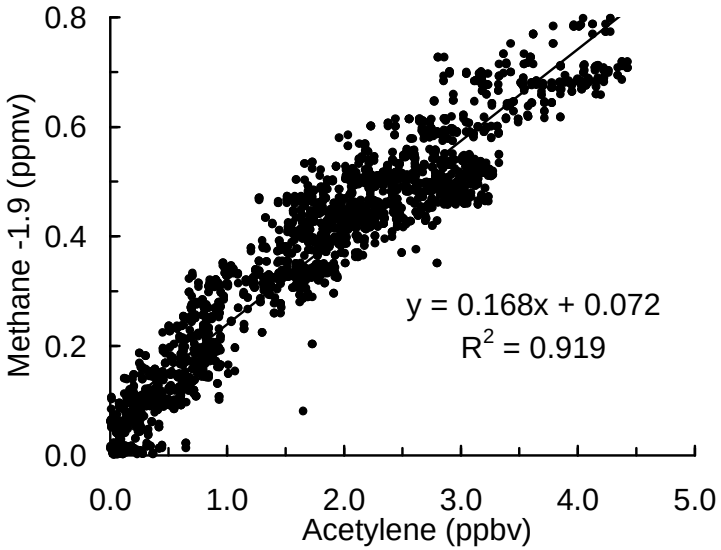
Mobile



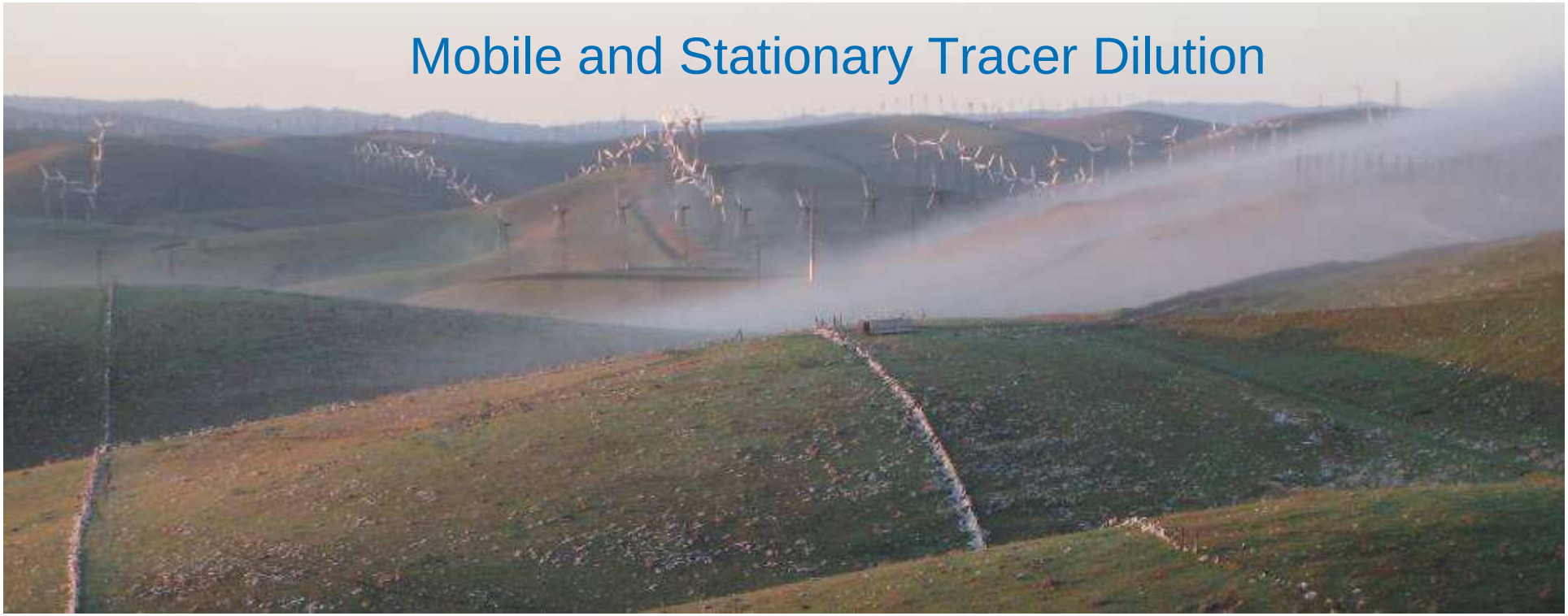


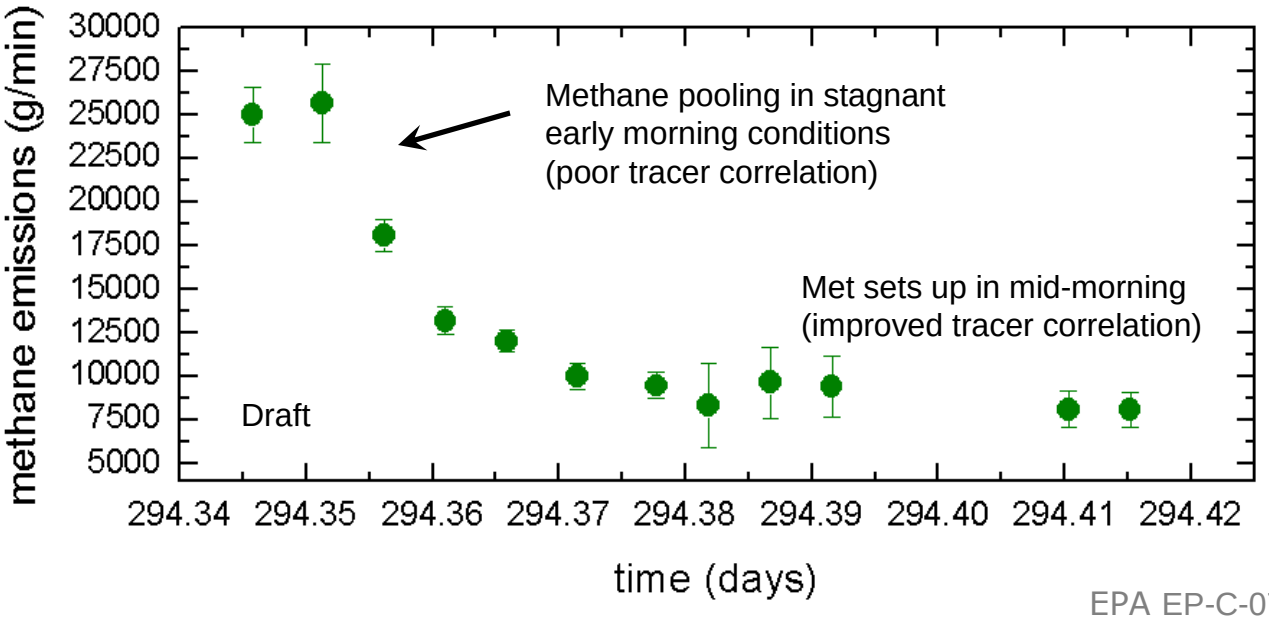
Stationary





Mobile and Stationary Tracer Dilution





EPA EP-C-07-15, WA 2-10 (2009)

Interesting Example:
CO_2 Sequestration Field monitoring

- Multiple Scales
  - Fugitive leaks from above ground equipment (facility)
  - Anthropogenic penetrations (distributed fugitive)
  - Detection and quantifications of emission from subsurface (large scale)
  - Ambient
- Multiple monitoring approaches required
- Isotope-based measurements are critical
- Subject of 2010 EPA Environmental Technology Verification

  http://www.epa.gov/etv/etvcurrent.html

Summary: Measurement of Fugitive and Area GHG Sources

- Direct source assessment is important
  - improve inventories, verify offsets, reduce emissions
- Research-grade tools exits
  - matching the tool to the task is critical
- Targeted method development is needed
  - User groups (academic, agency, commercial)
  - Use of data (research, verification, compliance?, process control)
- For many applications, implementation viability and costs are key